Study of Industry 5.0 Implementation to Achieve SDGs in Indian Electric Vehicle Manufacturing Organizations

A Synopsis Submitted to

Shri Vaishnav Vidyapeeth Vishwavidyalaya

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LIST OF ABBREVIATIONS

SDGs	Sustainable Development Goals
CE	Circular economy
I5.0	Industry 5.0
EVs	Electric Vehicles
SMEs	Small and Midsize Enterprises
UNOs	United Nations
GDP	Gross Domestic Product
IEEE	Institute of Electrical and Electronics Engineers
MDPI	Multidisciplinary Digital Publishing Institute
CSC	Circular Supply Chain
UHF	Ultra High Frequency
RFID	Radio Frequency Identification
IoT	Internet of Things
AI	Artificial Intelligence
MCDM	Multi-criteria decision making
AHP	analytical hierarchy process
DEMATEL	Decision-Making Trial and Evaluation Laboratory Model
TOPSIS	The Technique for Order of Preference by Similarity to Ideal Solution
VIKOR	VlseKriterijumska Optimizacija I Kompromisno Resenje (multi-criteria optimization and compromise solution)
MOORA	Multi-Objective Optimization on the basis of Ratio Analysis
OCRA	Occupational Repetitive Action
ANP	Analytic Network Process
ARAS	Additive Ratio Assessment
SPSS	Statistical Package for the Social Sciences
MATLAB	Matrix Laboratory
AMOS	Analysis of a moment structures

Study of Industry 5.0 Implementation to Achieve SDGs in Indian Electric Vehicle Manufacturing Organizations

1.Introduction

The Sustainable Development Goals (SDGs) were underlined as being in need of significant societal changes, which were made even more urgent by the pandemic's advent. The future civilization should strive for sustainable growth, a process in which technology is a key component (Kasinathan et al., 2022). The decoupling of environmental degradation from economic growth and doing more with less are two of the biggest global problems in integrating environmental sustainability with economic growth and welfare. To encourage sustainable consumption and production habits and to achieve the transition to a greener and more equitable global economy, resource decoupling and impact decoupling are required (Nahavandi, 2019). Respecting the biophysical limits of the earth and reducing present global consumption rates to fit with the biophysical ability to deliver ecosystem services and benefits are essential components of sustainable consumption and production practices (Nahavandi, 2019). An innovative concept known as "Industry 5.0" aspires to give society and the environment top priority in the growth of the industrial sector. Industry 4.0, which is centered on productivity fueled by technology, is said to fall short of delivering sustainable development, according to proponents (Lu et al., 2022). Industry 4.0, although accidentally enhancing certain aspects of micro-environmental sustainability, such as industrial effectiveness and emissions reduction, falls short of getting beyond the profit-driven nature of the current economic systems (Xu et al., 2021). Industry 4.0's detractors argue by emphasizing shareholder interests and profitability, it promotes neoliberal capitalism by escalating socio-environmental issues including regional inequality and ecological degradation. However, Industry 5.0 attempts to overcome these flaws by emphasizing environmentally friendly methods and social welfare (Duggal et al., 2021).

This will be the major issue that emerges when Industry 4.0's full impact is felt in a few years, as a result, it will encounter opposition from politicians and labor organizations, who will see some of the advantages of Industry 4.0 nullified as pressure to grow the employment number mounts. However, establishing process efficiency with cutting-edge technologies does not really need to be on the back foot (Nahavandi, 2019). Industry 5.0 is suggested as the remedy by fusing workflows with intelligent systems, the fifth industrial revolution will match people and machines to better exploit human creativity and brainpower and boost process efficiency. As automation is the key issue in Industry 4.0 while Industry 5.0 will be a collaboration between human beings and autonomous robots. The workforce will be independent and will be aware of human intention and desire. The human species will coexist with robots in the workplace without fear or apprehension because they are confident that their robotic colleagues fully comprehend them and can work cooperatively with them. It will lead to a production process that is incredibly effective and value-added, flourishing trustworthy autonomy, less waste, and lower associated expenses. The meaning of the word "robot" will change because of Industry 5.0. The fifth industrial revolution will better match humans and machines to utilize human creativity and brainpower and increase process efficiency by combining workflows with intelligent systems. It will result in a highly efficient and

value-added production process, thriving reliable autonomy, less waste, and fewer associated costs. As a result, the definition of the word "robot" will alter (Nahavandi, 2019). The Industry 5.0 revolution entails the coexistence of humans and robots, increasing the effectiveness of industrial output (Xu et al., 2021; Lu et al., 2022). Incorporating human-centric, sustainable, and resilient themes into the Industrial Revolution, Industry 5.0 is referred to as the revolution in which man and machine are figuring out how to increase the effectiveness of the production system (Imoize et al., 2021). Industry 5.0 is being created because of the growing merging of synthetic and human cognition. This decade places a high value on the interaction between human workers and robotic assistants, with people serving as the center. The transition from artificial intelligence models that eliminate jobs to adaptable business models supports new job opportunities. To ensure cooperative and controlled operations and incorporate human participation, administration sectors must match themselves with technology improvements. Human participation in automated processes enables a link between user needs and individualized production techniques. Flexible work arrangements might, however, have a detrimental effect on workers' wages and cause financial problems in today's culture (Duggal et al., 2021).

The Industrial Revolution saw a shift away from manual processes into complex, automated, networked systems. Steam power and equipment first appeared at the start of the First Industrial Revolution, increasing production by an astounding eightfold. Then came Industry 2.0, which combined mechanical and electronic equipment to create a more sophisticated industrial landscape. Partial automation was subsequently used in Industry 3.0, greatly boosting efficiency and dependability in the manufacturing sector. Industry 4.0 orchestrated the fusion of production with information and communication technology by building on these developments. Cutting-edge technologies like artificial intelligence and additive manufacturing were introduced by this groundbreaking combination, taking industrial processes into unexplored territory. The forefront of our development at the moment is Industry 5.0, which emphasizes cooperation between AI and humans. This paradigm change greatly emphasizes human-centricity, elevating meaningful labor to the forefront of the manufacturing industry. Cobots and other cutting-edge technologies like Network Sensor Data Interoperability take center stage, boosting accuracy and efficiency while empowering the workforce (Khan, et. al., 2023). Industry 5.0 appears as the next transformation in the industries, emphasizing human-machine cooperation while also considering ethical considerations. This innovative industrial idea explores the historical development of industrial revolutions from 1.0 to 4.0, illuminating their successes, constraints, and use of mathematical tools. Industry 5.0 may be defined as a movement that emphasizes social benefit, environmental protection, and human well-being in the industrial sector. The primary research question seeks to fully comprehend the essence of Industry 5.0, taking into account its objectives, all-encompassing strategies, human influences, facilitative technologies, and environmental concerns, with a focus on the interaction of humans and robots in the workplace and the development of an intelligent society (Akundi et al., 2022). Industry 5.0, sometimes referred to as the Age of Augmentation, is centered on the interaction between industrial machines and people. Industry executives were polled to learn more about how they perceive the transition from Industry 4.0 to Industry 5.0, with an emphasis on ethical issues and human-centric growth. Demonstrate practical uses for the incorporation of values

in design that successfully addresses moral issues (Longo et al., 2020). Establishing a highly efficient and socially responsible company structure is a key component of Industry 5.0, with the main objective of empowering employees and enhancing their work experiences. It is essential for guiding society toward more justice and fairness. While incorporating cutting-edge digital technology like robots and big data analytics is clearly beneficial for increasing productivity and efficiency. It may also present serious sustainability concerns, such as rising energy usage and emissions (Giovanni, 2023). The proposed research study explores the potential of technology to achieve SDGs through Industry 5.0 (Kasinathan et al., 2022).

1.1 Motivation behind the Present Research Work

The idea of Industry 5.0 revolves around the partnership between people and robots as allies in the industrial industry. The challenges that businesses face in increasing efficiency while including people in the process are the focus of the forthcoming industrial revolution. Robots play a crucial role in manufacturing as cutting-edge digital technologies and AI-driven solutions continue to advance, supported by new technologies like brain-machine interfaces. Industry 5.0 aims to create a collaborative environment where people and robots work side by side to maximize production and efficiency. It recognizes the value of human abilities, inventiveness, and problem-solving skills alongside the capabilities of robots. This strategy appropriately acknowledges that, while automation and AI offer enormous potential, engagement, and interaction. The creation of a novel, methodical, and developing digital strategy is therefore crucial. Due to the omission of environmental and social indicators from their plans, they are unable to achieve sustainable development (Ghobakhloo, 2020). That is why the research on Industry 5.0 approaches implementation to achieve SDGs.

1.2 Benefits and Challenges of Industry 5.0

Industry 4.0 has been accessible for the previous ten years to enhance the industry and its shortcomings; Industry 5.0 is now conceivable. In order to attain competitive advantages and economic success, industry 5.0 is required in the present business environment with the latest technological advancements. Industry 5.0 opportunities, limitations, and possible research areas. Industry 5.0 brings with it several new challenges that have never been seen before (Xun Xu et al., 2021), including-

- Social diversity in terms of recognized values.
- Evaluation of the creation of social and ecological value.
- Inclusion of SMEs from consumers along the whole value chain.
- System difficulty and research from multiple fields.
- Ecosystem-focused innovations strategy paired with flexible, result-driven development.
- Productivity is essential, but substantial expenditures are also required.

1.3 Sustainable Development Goals

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. The 17 Sustainable Development Goals (SDGs) suggested by UN-SDGs (2023) and Rao (2023), are mentioned here:

- ✓ *End poverty in all its forms everywhere.*

  This is the first goal of the United Nations is to eliminate extreme poverty by 2030. According to the United Nations, anyone who lives on 1.25 or below per day comes under extreme poverty.

- ✓ *End hunger, achieve food security and improved nutrition and promote sustainable agriculture*.

  This is the Second goal of the United Nations is zero hunger by 2030. The leading cause of death in the world is hunger. Our earth has given us a wealth of resources, but many people are starving due to inequitable access and ineffective management. With the use of cutting-edge technology and equitable distribution methods, we can support the global population and ensure that no one will ever again be hungry.

- ✓ *Ensure healthy lives and promote well-being for all at all ages.*

  This is the third goal of the UN emphasizes important objectives that improve the general health of a nation's people in order to reduce unnecessary suffering due to diseases that may be prevented as well as premature mortality.

- ✓ *Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.*

  By 2030, guarantee that all people have access to free, high-quality primary and secondary education, with gender bias eliminated and all people given equal opportunity. Promote equal access to pre-primary, technical, vocational, and postsecondary education as well to support human rights, global citizenship, and sustainable development.

- ✓ *Achieve gender equality and empower all women and girls.*

  When both males and females have the same opportunities, rights, and duties, this is referred to as gender equality. Sustainable development is defined as development that satisfies current demands without affecting the ability of future generations to satisfy their own needs (Rao B., 2023).

- ✓ *Ensure availability and sustainable management of water and sanitation for all.*

  The provision of a variety of services by water and sanitation, which are at the center of sustainable development, supports environmental sustainability, economic growth, and poverty

reduction. However, in recent years, overuse, pollution, and climate change have made many places throughout the world experience acute water stress.

- ✓ *Ensure access to affordable, reliable, sustainable, and modern energy for all.*

  Energy supply inaccessibility impedes both economic and human growth. Environmental resources such as sun, wind, hydropower, geothermal, biofuels, natural gas, coal, petroleum, and uranium are available as both renewable and non-renewable energy sources. In order to address the effects of global climate change, it is essential to enhance energy utilization, promote the use of renewable energy sources, and protect ecosystems, allowing the sustainable growth of hydropower and bioenergy.

- ✓ *Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.*

  This goal of the United Nations states that the realize full and productive employment, respectable employment for all women and men, including children and individuals with disabilities, and fair compensation for labor that is of equal worth by the year 2030.

- ✓ *Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.*

  The purpose of the Sustainable Development Goals is to promote economic growth and improve human well-being by building a durable infrastructure that is accessible to all. The main objective is to achieve just and sustainable industrialization, which creates job opportunities and raises GDP, particularly in the least developed nations. These objectives place a high priority on including small firms in supply chains, giving them access to funding, and promoting the adoption of clean, environmentally friendly technologies that maximize resource efficiency and industrial sustainability. Furthermore, the objectives focus on expanding scientific research, strengthening technical skills, and encouraging innovation, which calls for higher investment in the workforce involved in research and development as well as an increase in spending in this area.

- ✓ *Reduce inequality within and among countries.*

  Aim to of this goal is to exceed the national average in income growth for the poorest 40% of the population by 2030. Reduce inequality by promoting social, economic, and political inclusion for all people, regardless of their age, gender, handicap, race, ethnicity, religion, or economic condition. To create more equality, put in place fiscal, wage, and social protection measures that guarantee equal opportunity. Boost the representation of developing nations in decision-making, strengthen global financial system regulation, and promote safe and responsible migration through planned and regulated policies.

- ✓ *Make cities and human settlements inclusive, safe, resilient, and sustainable.*

Aim of this goal is to upgrade slums and provide everyone with sufficient, secure, and affordable housing as well as essential services by 2030. Enhance public transportation while putting a special emphasis on disadvantaged communities. Ensure safe, cheap, and sustainable transportation networks. Protect cultural and natural assets while advancing inclusive and sustainable urbanization and human settlement planning. Reduce the number of fatalities, financial losses, and environmental damage brought on by catastrophes, paying particular attention to vulnerable people. Give everyone access to public areas that are secure, welcoming, and green, especially women, children, seniors, and people with disabilities.

- ✓ *Ensure sustainable consumption and production patterns.*

The purpose of this goal is that, all nations will act, with industrialized nations taking the lead, by putting the 10-Year Framework of Programmed on Sustainable Consumption and Production Patterns into effect while taking into account the capacities of developing nations. By 2030, it is intended to achieve sustainable management and effective use of natural resources, as well as to decrease cooperative along supply chain operations global food waste in half. To reduce negative effects on health and the environment, ecologically appropriate management of chemicals and wastes shall be given top priority by 2020. Through prevention, recycling, and reuse, trash output will also be greatly decreased. Public procurement methods are in line with national sustainability regulations, and businesses are urged to implement sustainable practices and incorporate sustainability information into their reporting. By 2030, there will be widespread knowledge of sustainable development and eco-friendly lifestyles.

- ✓ *Take urgent action to combat climate change and its impacts.*

This goal include strengthening resilience and adaptation against climatically caused dangers and intrinsic disasters on a worldwide scale. This requires incorporating domestic policies, methods, and activities with global warming initiatives. Additionally, there is a clear focus on enhancing awareness, understanding, and skill development with relation to reducing the effects of climate change, adapting to them, and implementing early warning systems.

- ✓ *Conserve and sustainably use the oceans, seas and marine resources for sustainable development.*

The main aim of this goals are to prevent and reduce marine pollution brought on by human activities, sustainably manage and protect marine ecosystems, and address the problem of ocean acidification through enhanced scientific cooperation. The objectives also include regulating fishing methods, restoring fish populations, protecting coastal and marine areas, and gradually eliminating harmful fisheries subsidies. Finally, the goal is to increase economic benefits for Least Developed Countries and Small Island Developing States by encouraging the sustainable use of marine resources including fisheries, aquaculture, and tourism.

- ✓ *Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.*

  The main objectives of this goal are on preserving, rejuvenating, and wisely employing land-based and freshwater habitats, including woods, marshes, peaks, and dry regions. In order to achieve this, forest degradation must stop, sustainable forest management must be promoted, and forest establishment and restoration must be scaled up internationally. Additionally, actions are taken to stop land degradation, restore degraded soil and land, protect mountainous ecosystems and the variety they support, and protect endangered species. By 2020, efforts are also being made to promote the equitable distribution of genetic resources, combat wildlife trafficking, control the negative effects of invasive species, and seamlessly incorporate ecosystem and biodiversity values into national and local planning and development processes.

- ✓ *Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels.*

  The main objectives of this goal are to drastically reduce violent crime and the associated fatality rates worldwide, put an end to child abuse and coercion, promote the establishment of fair judicial systems and equal access to legal resources, and combat illegal money transfers and organized criminal activity. Additionally, efforts are made to prevent dishonesty, create accountable and transparent institutions, ensure inclusive decision-making processes, and increase the participation of developing countries in international governing organizations. Giving everyone legal status, ensuring free public access to information, and protecting fundamental liberties will all be priorities by the year 2030.

- ✓ *Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.*

  This goal aims in order to improve the ability of developing nations to collect taxes and create income, it is necessary to encourage the growth of domestic financial resources, attract foreign help, and promote investments in the least developed nations. Strengthening international collaboration in the areas of innovation, technology, and research is also essential for ensuring the favorable transfer of eco-friendly technologies to poor nations. Supporting initiatives intended to build capacity for attaining all of the Sustainable Development Goals through international collaboration is also essential.

2. Review of Literature on Industry 5.0 SDGs

This review of journal articles and industrial reports is based on a classification methodology. It is addressed as a basis for the conceptual and theoretical reference framework. The classification used in this literature review is explained below-

2.1 Method of study

Relevant publications are found with the help of a detailed online search with the aim of collecting, organizing, and synthesizing existing sustainable development goals knowledge. The knowledge of the research was also found from the United Nations Sustainable development goals data base the identified documents cover different types of interconnected disciplines including production engineering and industrial engineering. Using research queries in online databases is today the dominant method of identification of the most relevant works. It is more practical to focus on online databases rather than review library collections for a review of the literature in the sustainable development goal. Therefore, the following major online databases were the goal: Elsevier's Scopus, Thomson Reuter's Web of Science, IEEE Explore, and ProQuest (ABI / INFORM) and Science Direct (Elsevier), Sustainability (MDPI), Taylor & Francis. It is widely recognized and discussed among professionals. To include industrial relations, the Google search engine is also used for more to reach.

Table 1: Review of Literature on Industry 5.0 SDGs

S. No.	Authors name	Name of Journal /Publisher	Title	Objective	Finding	Limitations/Gaps
1	Ghobakhloo, et al. (2022)	Sustainable Production and Consumption (Elsevier)	Identifying industry 5.0 contributions to sustainable development: A strategy roadmap for delivering sustainability values.	This research paper focused on complexity reduction, while social sciences and psychology tend to increase it by coming up with even more impacting factors and dimensions.	The present study identified functions through which Industry 5.0 might potentially deliver its intended sustainable development values	In This research, the roadmap is limited to the contextual properties under which it has been developed, particularly concerning the experts' demographics.
2	Dwivedi, Ashish Agrawal et al. (2022)	Computers & Industrial Engineering	Studying the interactions among Industry 5.0 and circular supply chain: Towards attaining sustainable development.	This research paper focused the current study pinpoints 16 key drivers for achieving I5.0 and CSC synergy. The criticality strength of drivers was determined using a mixed model is created using the Cross-Impact Matrix Multiplication Applied to Classification and the modified Total Interpretive Structure Model (m-TISM). While The detailed assessments specific to the drivers' reliance and driving ability are organized by MICMAC, m-TISM arranges the binary interactions between the drivers.	According to the study, the factors with the greatest potential for influence are "Management support for circular supply chain and Industry 5.0 transition" "The organization preparedness and anticipation in the move to circular supply chain and Industry 5.0," and as a result, they should be given top priority when creating the implementation plan. Further, the The top-level drivers in the analysis include the driving aspect "Attitudinal transition of consumers towards CSC and I5.0 models," highlighting the significance of raising knowledge and changing attitudes in order to implement this business process change.	For sustainable development, the current study is restricted to 16 drivers using I5.0 and CSC. Additional drivers might be gathered for upcoming research It is possible to undertake empirical statistical Future research may select experts from many fields to provide their recommendations.

3	Battini Daria (2022)	International Journal of Production Economics (Elsevier)	Towards industry 5.0: A multi-objective job rotation model for an inclusive workforce	The main objective of this paper is to prepare a best fit assignment job while considering the individual flexible rest- break plan for each worker.	The result shows that Workers evaluated the resemblance of various vocations by thoroughly examining three separate situations. A more regular rotation of shifts an improvement in productivity and a decrease in boredom, The three-rotation shift was found to be the most productive in the second scenario, when the occupations were judged to be distinct. offered the best balance between productivity and little tedium.	There is need to develop a metaheuristic approach to reduce computational time for large instances and test the method in other industrial sectors. Also, for Future investigations will finally take in consideration the effect of different learning curve shapes and the training costs to accelerate the learning process in different jobs.
4	Xun Xu et al. (2021)	Journal of Manufacturing System (Elsevier)	Industry 4.0 and Industry 5.0—Inception, conception and perception	In this paper, both Industry 4.0 and Industry 5.0, which calls for talks and explanation, raise questions. In order to structure our points of view, we choose to employ five of these questions. , and we made an effort to be objective when choosing informational sources and when having debates about the important problems.	In this paper after discussion on various aspects related questions final words is that the Industry 4.0 is technology-driven and the Industry 5.0 is the value-driven.	In the research it is mentioned that further more study required or the depth discussion should be done on Industry 4.0 and Industry 5.0 like Industry 6.0 and Industry 7.0.
5	Swastik Angel Duggal et. al. (2021)	IET Communications WILEY	A Sequential roadmap to Industry 6.0: Exploring future manufacturing trends	This paper aims to Highlight the focus area of Industry 5.0 and through it prepare a suitable way to achieve Industry 6.0.	In this research the study of application of Industry 6.0 on Medical Technology and automation is discussed.	The limitation of this research is that the automated capital generation via robotic manufacturing on mass production scale is not practicable.

6	Lamas Paula Fraga-et. al. (2021)	IEEE ACCESS	Next Generation Auto-Identification and Traceability Technologies for Industry 5.0: A Methodology and Practical Use Case for the Shipbuilding Industry	This paper analyzes and evaluate the passive and active UHF RFID hardware and software of selected component through Auto-ID technology for ship building industry	The result indicates that Passive UHF RFID was appropriate for traceability application while active RFID used for inventory management.	Auto -ID technology is mainly dependent on specific use case and technologies are rapidly evolving,
7	Nehavandi Saeid (2019)	Sustainability (MDPI)	Industry 5.0- Human -Centric Solution	This paper introduces the idea of Industry 5.0, where robots act as collaborators rather than competitors by becoming integrated with human brains. also a few important aspects of Industry 5.0 and some potential issues that every producer might have. Additionally, it highlights a number of research-based advancements for apply in Industry 5.0 applications and situations.	The implications of Industry 5.0 on the manufacturing sector and broader economy are examined from the perspectives of productivity and the economy. According to some, Industry 5.0 will generate more jobs than it will remove.	In this paper barriers to which achievement of the industry 5.0 is not missing.
8	Umar Al Faruqui (2019)		Future Service in Industry 5.0	This Survey research paper aims to explain the Industrial revolution by utilization of both era Industry 4.0, Industry 5.0 and human involvement.		
9	Destouet et. al. (2023)	Journal of Manufacturing Systems	Flexible job shop scheduling problem under Industry 5.0: A survey on human reintegration, environmental consideration and	Aim of this paper is to introduces the Sustainable Flexible Scheduling Problem (SFJSSP) as a human and energy-efficiency-centered scheduling problem. First, we review the last decade's	This paper presents a survey of FJSSP considering the environmental and human factors. We start by introducing the evolution of scheduling problems, particularly in the last	This paper reviewed and analyzed how human and environmental factors are considered in the literature of FJSSP. The scheduling models and methods were

			resilience improvement	literature on Flexible Job Shop Scheduling Problems (FJSSP) with human and/or environmental considerations. Next, we analyze the development trends in manufacturing scheduling problems. Finally, we discuss future research challenges to move towards scheduling 5.0 and suggest a mathematical model that considers human and environmental factors (in addition to the factors considered by the Classical Flexible Job Shop Scheduling Problem (CFJSSP)).	decade from the emergence of Industry 4.0 to now. Scheduling problems have been widely studied in the literature under different production types, characteristics, environments, and objective functions. This interest is due to the high impact that scheduling has on the production process. FJSSP is the most encountered in	transformed by the arising of Industry 4.0 concepts and technologies and are nowadays challenged by the new concerns related to the human-centricity and environment efficiency of the current Industry 5.0 context. Looking at our analysis, only few papers consider the sustainable (economic–human–environment) scheduling problem,
10	Praveen Kumar Reddy Maddikunta et. al. (2021)	Journal of Industrial Information Integration	Industry 5.0: A survey on enabling technologies and potential applications	Aim of this paper is to survey the implicit application of Industry 5.0 in various field of manufacturing also discuss the future research difficulties	Industry 5.0 is a theory that aims to consistently balance the productivity of people and machines in the workplace. Enabled Industry 5.0 is anticipated to boost manufacturing output and customer satisfaction through a variety of new applications and supporting technology. We have listed a number of difficulties and unresolved problems that need to be addressed in order to fully actualize the idea of Industry 5.0 in the near future, including security, privacy, human-robot	

					collaboration in a production, scalability, and skilled labor.	
11	Khan Moin et. al. (2023)	Green Technologies and Sustainability (KeAi Chinese Root Global Impact)	Changes and improvements in Industry 5.0: A strategic approach to overcome the challenges of Industry 4.0	Industry 4.0's problems with data privacy and technical integration have been addressed in 5.0. Resilience is another essential component of Industry 5.0, which promoted hyper-individualization and enabled the creation of products tailored to the demands of individual customers	Research opportunities are enormous thanks to Industry 5.0, particularly in the areas of data security and integration, which are regarded as the biggest obstacles to the Industrial Internet of Things. For Industry 5.0, better sustainability concepts can also be developed. As a result of automation and digitization, it is now simpler to analyze the data collected by sensors employed in many sectors of industry in order to remove obstacles to raising organizations' productivity and efficiency.	challenging to research the constraints and difficulties presented by Industry 5.0 technologies. Future research can be done to identify the difficulties Industry 5.0 technologies encounter and come up with a workable solution.
12	ElFar et. al. (2020)	Energy Conversion and Management: X (Science Direct)	Prospects of Industry 5.0 in algae: Customization of production and new advance technology for clean bioenergy generation	The aim of the paper is to . The use of genetic engineering techniques in algal production to produce bioenergy and byproducts was also investigated. One area of attention was the identification of the appropriate algae strain using automated genetic manipulation and genetic alteration. Additionally, the effects of Industry 5.0 on	Industry 5.0 in the microalgae industry provide the benefits to environment also the quality of product is improved. By applying PBR modal in microalgae culture carbon emission can be controlled.	Implementation of a modern technological development is unpredictable, since its possibility of building, and its likelihood of deconstruction is the product of a specific transition..

				new business prospects, the environment, and the potential of reaching SDGs were discussed.		
13	Alvarez-Aros, et. al. (2021)	Annals of the Brazilian Academy of Sciences (Engg. Science)	Technological competitiveness and emerging technologies in Industry 4.0 and Industry 5.0	industry 4.0 and industry 5.0's rising technologies and technical competitiveness are comprehensively examined to determine the essential components of industrialized economies. Biblioshiny was used for this bibliometric study, and a thorough assessment of the literature and content analysis were conducted.	By two approaches developed economies and emerging economies in developed economies, elements like the competences, abilities, and skills of the personnel are more oriented to engineering techniques such as STEM in the emerging economies, the need to develop the general skills of the persons is raised, Despite the fact that it is not the most important issue and does not require the same level of dedication as in developed countries, this necessity.	In future research, it is suggested to include intellectual property information and patents, and use techniques such as the Delphi method with experts. This document identified the key elements of technological competitiveness and the most used emerging technologies in developed and emerging economies, so it represents a starting point, especially in emerging economies for entrepreneurs, academics, and policymakers
14	Sandra Grabowska et. al. (2022)	Springer	Industry 5.0: improving humanization and sustainability of Industry 4.0	The goal is to pinpoint issues with the humanization and viability of the Industry 4.0 idea. Web of Science was analyzed bibliometrically utilizing Vosviewer tools, Excel, and content	In this paper identifies the flaws in the idea of Industry 4.0, particularly when it comes to the place of humans in intelligent manufacturing and sustainable growth. As a result, the notion of	In order for human values and ethical considerations to be addressed as design needs rather than expenses in freshly created cyber-physical systems, it is necessary

				examination of particular papers.	Industry 5.0's framework was found. The bibliometric study that was conducted also made it possible to pinpoint a crucial area for worker skill development.	to analyze them in advance. the study of how humans participate in industrial digitalization operations, the field of creating the industrial 5.0 concept, and the development of the economy 4.0 and society 5.0, all in the framework of sustainable development. The lack of study on the social, ecological, and economic effects of the Industry 4.0 concept might not go over well with certain individuals. No possibilities of Society 5.0's future operations exist at this time.
15	Nahavandi Saeid, et. al. (2019)	Sustainability (MDPI)	Industry 5.0—A Human-Centric Solution	The paper's focus is on the idea of Industry 5.0, in which robots collaborate with humans rather than competing with them. Describes several important aspects of Industry 5.0 as well as some potential worries that every company could have. Additionally, it highlights a number of research-based advancements for usage in Industry 5.0 contexts and applications. From an economic and production	Three key components—intelligent devices, intelligent systems, and intelligent automation—fully converge with the physical environment in collaboration with human intelligence, the Fifth Industrial Revolution will begin. The word "automation" refers to autonomous robots that operate alongside people simultaneously in the same workspace. Between these two parties, trust and	Given that Industry 5.0 will bring robots so close to the daily activities of any human, it will provide HMI with previously unheard-of obstacles. Even if we are infatuated with machines like programmable assistive devices and programmable autos, we do not view them as cobots (despite the fact that there are some

				perspective, the impact of Industry 5.0 on the production industry and broader economy are explored. It is suggested that Industry 5.0 will generate more employment than it would eliminate.	dependability will lead to manufacturing that is flexible, efficient, and waste-free. By doing this, it will encourage more individuals to return to their jobs and increase the effectiveness of the workflow.	minor differences), primarily due to their design. Cobots will be quite different because of the way they are designed and developed, which includes human-like functionalities like grasping, pinching, and interacting based on user intent and external circumstances. We also believe that Industry 5.0 will lead to a significant increase in employment opportunities in the HMI and computational human factors (HCF) analytical fields.
16	Kasinathan P et. al. (2022)	Sustainability (MDPI)	Realization of Sustainable Development Goals with Disruptive Technologies by Integrating Industry 5.0, Society 5.0, Smart Cities and Villages	The aim of the research examining its results through product creation, health care transformation, a pandemic case study, nature-inclusive business models, and smart cities and villages, this report seeks to present the disruptive technologies to reach the SDGs. And result mapped with SDGs 3,8, 9,11, Industry 5.0 and society 5.0 are the two main terms to achieve SDGs The suggested	In this research, the effects of innovative technologies are further examined in terms of product creation, healthcare reform, a case study of a pandemic, nature-inclusive business models, and smart cities and villages.	The methods used to achieve these goals will pave the way for a new society in which people do not experience poverty, inequality, or conflict. Understanding the scientific truths that underpin the connection between nature and humans is critically important.

				integrated strategy to achieving the Sustainable Development Goals is evaluated using a SWOT analysis. In the end, this study can help business leaders, decision-makers, and scholars visualize the Sustainable Development Goals from a technical standpoint.		
17	Elpidio Oscar Benitez Nara et. al. (2020)	Sustainable Production and Consumption	Expected Impact of Industry 4.0 Technologies on Sustainable Development: A study in the context of Brazil's Plastic Industry	utilizing the Triple Bottom Line approach to sustainable development. It is suggested to use a sustainability-focused methodology to assess how Industry 4.0 technologies have affected sustainable measures. This model examines how various important performance indicators for sustainable development are affected by Industry 4.0 technologies. The approach was evaluated in the plastics sector, which in emerging nations has a significant potential for technical aggregation under Industry 4.0. Industry 4.0 technologies were categorized using a fuzzy TOPSIS multi-criteria method to determine which ones had the greatest and least positive effects on sustainable development.	Result of the study shows 4 advances impact of the main Industry 4.0 technologies on individual KPIs related to sustainable development 2nd Second, it was shown that the IoT, CPS, sensors, and big data analytics may help industries thrive sustainably. Thirdly, by understanding and estimating the projected influence of each technology on KPIs pertaining to sustainable development, managers, process engineers, and stakeholders can benefit from this effort. Finally, scholars can use our findings to deepen their understanding of how various Industry 4.0 technologies affect various KPI variables.	Future studies should look into determining the variables that influence the environmental and social elements of Industry 4.0 technologies in order to boost revenue, market share, and customer numbers. Through case studies and experimental studies, we also urge academics to examine other advantages and benefits that digital technology can have for environmental and social factors.

18	Eija Kaasinen, et. al. (2022)	Sustainability (MDPI)	Smooth and Resilient Human–Machine Teamwork as an Industry 5.0 Design Challenge	Aim of this paper is to examine this design problem and suggest that the design be based on the joint cognitive systems strategy. With approaches that enable human centricity in the early stages of design and the creation of continually co-evolving human-machine teams, the established joint cognitive systems approach can be supplemented. We suggest methods for observing and evaluating human-machine teamwork, creating the operational idea with key stakeholders, and including moral considerations into design and development. Our study is based on the combined cognitive systems approach, and we suggest additional methodologies, including actor-network theory, the idea of operations, and morally conscientious design. We discuss the advantages and disadvantages of building effective human-machine teams for Industry 5.0 manufacturing systems.	The concept of operations design approach can be used as a complement to the heavier cognitive systems engineering approach, particularly in the early design stages. The ConOps strategy encourages the participation of various stakeholders in the design of the system's overall functionality and operating principles. ConOps documents make it easier to share and collaborate on design concepts for both the main system and various subsystems.	Future work of this paper is how successfully the strategies and techniques suggested here will function in actual practice. Studying how to keep track of and direct a joint human-machine system's ongoing co-evolution will be particularly interesting.
20	Omar Ashraf ElFar et. al. (2021)	Energy Conversion and Management: X	Prospects of Industry 5.0 in algae: Customization of production and new	The main aim of the papers is the production and processing of algae from an industrial perspective,	It is hoped that using the new, advanced PBR models in microalgae production could	In manufacturing, Industry 5.0 places a strong emphasis on the return of human hands,

			advance technology for clean bioenergy generation	algae analyzing in Industry 4.0, and the transition from Industry 4.0 to Industry 5.0 are discussed in this paper, along with economic and environmental analysis of the production of algae-derived bioenergy, variation of the bioenergy made from algae, algae farming, and modifications to the growing method. The use of genetic engineering techniques in algal production to produce bioenergy and by products was also investigated. One area of focus was the identification of the appropriate algae strain using automated genetic manipulation and genetic alteration. Additionally, a large amount of research was done on the effects of Industry 5.0 on new business prospects, the environment, and the potential of reaching SDGs.	significantly lower carbon emissions from industry and even lead to zero carbon discharges. Additionally, as we get toward Industry 5.0, genetically modified algae will significantly contribute to strain modification. The Industry 5.0 also has an impact on the algal economy by altering production practices, changing the demand for biofuels through customized bioenergy, and reshaping the market in order to achieve the SDGs.	brains, and intuition. It also emphasizes the conversion of factories into smart IoT facilities that use semantic processing and network systems via cloud servers. In order to boost industrial capacity and performance, Industry 5.0 has the potential to make peace between humans and robots and look for cooperative ways to work together Modern technical development implementation is uncertain,
21	Pietro De Giovanni (2023)	Sustainability (MDPI)	Sustainability of the Metaverse: A Transition to Industry 5.0	This study offers resources to manage the shift to Industry 5.0 responsibly through a responsible digital transformation path through the metaverse. It provides a set of frameworks for examining the metaverse from a variety of perspectives, including the triple bottom	. These tools enable readers to understand how society at large can responsibly implement, adopt, and manage a metaverse. By utilizing these frameworks, businesses can identify the most impacted strategies and take action to	This analysis provides a general framework for future research and practitioners in evaluating the adoption of the metaverse by highlighting the emerging tradeoffs. Future research should be

				line, environmental, social, and governance (ESG), the most impacted business strategies, and the technology's relationship to the Sustainable Development Goals (SDGs).	address any potential negative impacts	developed to verify how these tradeoffs can be solved and to propose viable solutions for society at large
22	Aditya Akundi et. al. (2021)	Applied System Innovation (MDPI)	Article State of Industry 5.0—Analysis and Identification of Current Research Trends	Aim of this paper is to utilizing text mining techniques and methods to find and evaluate the many topics and study trends of what Industry 5.0 is. In order to do this, 196 published articles' abstracts from searches conducted using the keywords "Industry 5.0" in the IEEE, science direct, and MDPI databases were retrieved. Prior to further analysis using text-mining techniques such as key phrase extract and frequency evaluation, data cleaning and preparation were carried out. Additional topic mining, or unsupervised machine learning, was employed to further explore the data.	It has been noted that among the many enablers identified by academics to propel Industry 5.0, the phrases artificial intelligence (AI), big data analytics, supply chain, digital transformation, machine learning, and internet of things (IoT) are among the most often used. The published literature was categorized into five key themes of Industry 5.0: supply chain evaluation and optimization, enterprise innovation and digitization, smart and sustainable manufacturing, transformation driven by IoT, AI, and Big Data analytics and human-machine connectivity. These themes highlight potential future research topics. It has been noted that the scientific community has recently been increasingly interested in the idea of Industry 5.0 as a bridge to human-machine	By comprehensive analysis along with integration of data crawling techniques will provide a better perspective on what Industry 5.0 is and how it is perceived among the research community.

					communication and coexistence.	
23	Elias G. (2021)	Journal of the Knowledge Economy	The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities	Aim of paper, make the case that digitalization gives universities new opportunities and can serve as one of the primary catalysts for transformation in this sector. Universities and societies will both be able to fully benefit from digital transformation if the assumptions of Society 5.0 and Industry 5.0 are included into the practices and policies of higher education institutions. It will also help to attain sustainable aims if universities make human-centered innovation their brand and create new collaboration models. The Quintuple Helix Model (QHM), which incorporates several views and establishes sustainability priorities and considerations, may encourage the process of necessary transformations.	This paper finding the connections between the Q2HM framework, Industry 5.0, and Society 5.0 principles. By exploring the main definitions and their implicit meanings for the future socially and digitally engaged university paradigm, we introduce I5.0 and S5.0. A few restrictions relating to our study can be found. The originality of the Industry 5.0 and Society 5.0 ideas immediately informs the first set of outcomes.	Additional study might look at how the theoretical underpinnings of Industry 5.0 and Society 5.0 have been put into practice (not just within specific communities or places, but also within particular studies, instruction, or promotional efforts and projects). By integrating human-machine relationships and putting environmental and ecological concerns front and center in ecosystems for innovation, this will also pave the way for tackling new forms of digital and social innovation.
24	Elias G. et. al. (2021)	Journal of the Knowledge Economy	Towards Fusion Energy in the Industry 5.0 and Society 5.0 Context: Call for a Global Commission for Urgent Action on Fusion Energy	In this paper, the geopolitical status quo of nuclear fusion energy is reviewed at a high level, and a future vision is presented in light of Industry 5.0 and Society 5.0. ITER, the largest fusion experiment in the	The fusion version of the Acheson-Lilienthal report could kick-start a global "Fusion for Peace" program to roll out "energy for all," the dream embodied in the Baruch Plan and	

				world, started assembling its machine 2020, the year of Hiroshima and Nagasaki's 75th anniversaries. The official start date for the DEMO (fusion power) stage of ITER planning is 2019. We underline that a self-sustaining fusion reaction event involving "burning plasma" will mark an important turning point comparable to the Trinity Test.with numerous nations currently involved in the creation of DEMO-phase machines.	now in the UN's Sustainable Development Goals, and also help address climate change. In the Commission, this would be achieved not through aid but via the kind of geopolitical and socioeconomic statecraft that opportunity provides once a century, or in Baruch's own words, the chance "to make a choice between the quick and the dead	
25	Erick L. et. al. (2021)	ENGINEERING SCIENCES	Technological competitiveness and emerging technologies in industry 4.0 and industry 5.0	This has a bibliometric analysis with Biblioshiny, a thorough literature review, and a content analysis as its goals.	The findings regarding technological competitiveness in developed economies highlight the significance of engineering and personnel competencies, R+D+i and the supply chain in organizational approaches, and the use of emerging technologies like the internet of things and big data analyics. The contrast with developing nations' economy highlights the significance of fundamental components like education and training for employees, organizational structure and sustainability, and cutting-edge technology	The cutting edge of technology and a thorough grasp of the supply chain are not given priority.

					like the internet of things and digitization.	
26	Paula et. al. (2021)	Sensors (MDPI)	Green IoT and Edge AI as Key Technological Enablers for a Sustainable Digital Transition towards a Smart Circular Economy: An Industry 5.0 Use Case	This article deals with this problem by exploring the different aspects that impact the design and development of Edge-AI G-IoT systems. Moreover, it presents a practical Industry 5.0 use case that illustrates the different concepts analyzed throughout the article. Specifically, the proposed scenario consists in an Industry 5.0 smart workshop that looks for improving operator safety and operation tracking. Such an application case makes use of a mist computing architecture composed of AI-enabled IoT nodes.	After describing the application case, it is evaluated its energy consumption and it is analyzed the impact on the carbon footprint that it may have on different countries. Overall, this article provides guidelines that will help future developers to face the challenges that will arise when creating the next generation of Edge-AI G-IoT systems.	Additional Mechanism, Future Communication network, Infrastructure, storage, visibility and Co2 emission minimization. These all are the challenges or limitation of Edge-AI G-IoT.
27	Francesco et. al. (2020)	Applied Science (MDPI)	Value-Oriented and Ethical Technology Engineering in Industry 5.0: A Human-Centric Perspective for the Design of the Factory of the Future	This paper argues that a value-oriented and ethical technology engineering in Industry 5.0 is an urgent and sensitive topic as demonstrated by a survey administered to industry leaders from different companies. The Value Sensitive Design (VSD) approach is proposed as a principled framework to illustrate how technologies enabling	Use cases based on real solutions and prototypes discuss how a design-for-values approach aids in the investigation and mitigation of ethical issues emerging from the implementation of technological solutions and, hence, support the migration to a symbiotic Factory of the Future.	Future research is necessary but is not explored in this work. Although not thorough, the survey's findings are applicable to numerous businesses and industries. It may be necessary to conduct cross-cultural or cross-national comparisons to find commonalities and differences in the specificity of value

				human–machine symbiosis in the Factory of the Future can be designed to embody elicited human values and to illustrate actionable steps that engineers and designers can take in their design projects.		systems. Researchers have demonstrated how a value system is dynamically changed by socio-cultural elements, changes in the workplace, and changes in industrial activities rather than being completely constant.
28	Zainab et. al. (2022)	Appl. Science	Production Plant and Warehouse Automation with IoT and Industry 5.0	This paper introduces a detailed overview of IoT in enabling digital transformations and Industry 4.0. The authors have discussed the application of IoT in different industrial sectors, and how the concept of IIoT has evolved.	In addition to this, the present paper highlights several research studies that enable the authors to elicit the major challenges, implementation analysis, and future scope of IIoT.	There are 3 limitations of this system Cyber security and data analytics i.e. Privacy and security is required, second one combination of blockcahin and IoT is very much required and lastly Cyber-Physical Production Systems improvement in software is needed.
29	Aditya et. al. (2022)	Appl. Syst. Innovation	State of Industry 5.0—Analysis and Identification of Current Research Trends	This serves as the motivation of this paper in identifying and analyzing the various themes and research trends of what Industry 5.0 is using text mining tools and techniques. Toward this, the abstracts of 196 published papers based on the keyword We retrieved results from the "Industry 5.0" search in the IEEE, Science Direct, and MDPI data bases. Prior to further	It has been noted that the scientific community has been more interested in the topic of Industry 5.0 as a bridge to human-machine interaction and coexistence in recent years.	Industry 5.0 in context ofsupply chain evaluation and optimization in manufactur-ing processes, Industry 5.0 in context of enterprise management, innovation, and digitization, Industry 5.0 in context ofsmart and sustainable manufacturing, Industry 5.0 transformation driven

				analysis using text mining techniques such as key phrase extraction and frequency analysis, data cleaning and preprocessing were carried out. Additional topic mining, or unsupervised machine learning, was employed to further explore the data. It has been noted that among the many enablers identified by academics to propel Industry 5.0, the phrases artificial intelligence (AI), big data analytics, supply chain, digital transformation, machine learning, and internet of things (IoT) are among the most often used. Among the published articles, there were five key topics of Industry 5.0 that were categorized as: supply chain review and optimization, enterprise innovation and digitalization, smart and sustainable manufacturing, transformation driven by IoT, AI, and Big Data Analytics, and human-machine connectivity.		by IoT, Bigdata, and AI, and Human machine connectivity and co-existence continuously improvement is required.
30	Vural et. al. (2018)	OMICS A Journal of Integrative Biology	Birth of Industry 5.0: Making Sense of Big Data analytics with Artificial Intelligence, ‘‘The Internet of Things’’ and Next-	Aim of this study, Industry 5.0 that can democratize knowledge coproduction from Big Data analytics, building on the new concept of symmetrical	Finding in research considers the technology opportunity costs, ethics, ethics-of-ethics, framings (epistemology), independence, and	

			Generation Technology Policy	innovation. Industry 5.0 utilizes IoT, but differs from predecessor automation systems by having three-dimensional (3D) symmetry in innovation ecosystem design: (1) a built-in safe exit strategy in case of demise of hyperconnected entrenched digital knowl edge networks. Importantly, such safe exists are orthogonal—in that they allow ‘‘digital detox’’ by employing pathways unrelated/unaffected by automated networks, for example, electronic patient records versus material/ article trails on vital medical information; (2) equal emphasis on both acceleration and deceleration of inno vation if diminishing returns become apparent; and (3) next generation social science and humanities (SSH) research for global governance of emerging technologies: ‘‘Post-ELSI Technology Evaluation Research’’ (PETER).	reflexivity of SSH research in technology policymaking. Industry 5.0 is poised to harness extreme automation and Big Data analytics with safety, innovative technology policy, and responsible implementation science, enabled by 3D symmetry in innovation ecosystem design	
31	Peter Sachsenmeier, (2016)	Engineering Science Direct	Industry 5.0—The Relevance and Implications of	This article describes a timeline that starts with current projects and then moves on to code	This article provides a general taxonomy in which the development of	

			Bionics and Synthetic Biology	engineering projects and their implications, artificial DNA, signaling molecules, and biological circuitry. Beyond these projects, one of the next frontiers in bionics is the design of synthetic metabolisms that include artificial food chains and foods, and the bioengineering of raw materials; all of which will lead to new insights into biological principles. Bioengineering will be an innovation motor just as digitalization is today. This article discusses pertinent examples of bioengineering, particularly the use of alternative carbon-based biofuels and the techniques and perils of cell modification. Big data, analytics, and massive storage are important factors in this next frontier. Although synthetic biology will be as pervasive and transformative in the next 50 years as digitization and the Internet are today, its applications and impacts are still in nascent stages.	bioengineering is classified in five stages (DNA analysis, bio-circuits, minimal genomes, protocells, xenobiology) from the familiar to the unknown, with implications for safety and security, in dustrial development, and the development of bioengineering and biotechnology as an interdisciplinary field. Ethical issues and the importance of a public debate about the consequences of bionics and syn thetic biology are discussed.	

32	Patrick et. al. (2022)	ScienceDirect	Human-centricity in the design of production planning and control systems: A first approach towards Industry 5.0	In this sense, there exists a dearth of study in the areas of PPC and Contextual Biases. Therefore, with this effort, we wish to make the initial move in the direction of the human-centered approach.	In this paper a systematic literature review and develop a questionnaire to determine the human-centered maturity level.	The results will then be compared with already researched Cognitive Biases.
33	Mary Doyle-Kent et. al. (2021)	IFAC Science Direct	Adoption of Collaborative Robotics in Industry 5.0. An Irish industry case study	"Collaborative robotics in Industry 5.0" data were gathered for a case study in the south east of Ireland by the author of this paper. The results serve to provide an interesting benchmark for collaborative robotics in Irish industry.	A brief summary of some of these results is shared here as well as ta novel conceptual framework and definition of Industry 5.0	there is a scope to improve how this is enabled in the plant. Two overarching questions emerge from the data presented here are: if a company doesn't currently have Cobots in their plant how can this knowledge gap be filled and if the company does have Cobots in their plant how can maximize value and customer Satisfaction.
34	Sandra Grabowsk et. al. (2022)	Scientometrics	Industry 5.0: improving humanization and sustainability of Industry 4.0	The article's goal is to pinpoint issues with the humanization and sustainability of the Industry 4.0 idea. The Web of Science was subjected to a bibliometric examination utilizing Vosviewer tools, Excel, and content analysis of chosen publications.	The analysis of the dynamics of the rise in publications in the Industry 4.0 and Industry 5.0 segments is one of the most significant findings. The essay identifies the flaws in the idea of Industry 4.0, particularly when it comes to the place of humans in intelligent manufacturing	Investigations into the idea of Industry 5.0, a look at how humans fit into the process of industry digitalization, and the expansion of economy 4.0 and society 5.0 within the context of sustainable development are all necessary. The lack of

					and sustainable growth. As a result, the notion of Industry 5.0's framework was determined. Additionally, the completed bibliometric research allowed for the identification of a crucial employee skill development stream.	study on the social, ecological, and economic effects of the Industry 4.0 idea may not sit well with certain individuals. No possibilities of Society 5.0's future operations exist at this time.
35	Lu et. al. (2022)	Journal of Manufacturing Systems	Outlook on human-centric manufacturing towards Industry 5.0	The paper presents our arguments on the concept, needs, reference model, enabling technologies and system frameworks of human-centric manufacturing, providing a relatable vision and research agenda for future work in human-centric manufacturing systems.	We believe human-centric manufacturing should ultimately address human needs defined in an Industrial Human Needs Pyramid – from basic needs of safety and health to the highest level of esteem and self-actualization. In parallel, human-machine relationships will Yuqian change following a 5C evolution map – from current Coexistence, Cooperation and Collaboration to future Compassion and Coevolution. As such, human-centric manufacturing systems need to have bi-directional empathy, proactive communication and collaborative intelligence for establishing trustworthy human-machine coevolution relationships, thereby leading to high-performance human-	In order to move toward human-centric manufacturing, technologies must be designed to operate for people in a reliable and welcoming manner because people are crucial to the creation of high-value customized products. The creation and application of enabling technologies in the actual world must be driven by philosophical, social, and ethical challenges and ideas.

					machine teams. It is suggested that future research focus should be on developing transparent, trustworthy and quantifiable technologies that provide a rewarding working environment driven by real-world needs.	
36	Valeria Orso a et. al. (2022)	Computers & Industrial Engineering	Employee-centric innovation: Integrating participatory design and video-analysis to foster the transition to Industry 5.0 video-analysis to foster the transition to Industry 5.0	In the present work, we describe a case study that was meant to re-design the technology used in a validation laboratory. We adopted a mixed-method approach integrating employee's self-reported data and objective event-based data from in-the-field video-analysis.	By doing this we could build a thorough understanding of the work activities and of the related main issues. We then devised a list of re-design recommendations that were translated in a revised application and in the suggested introduction of portable devices. The outcomes of a preliminary usability evaluation of the revised application were promising, indicating the effectiveness of the methodological approach	Among the limitations of the study, we have to acknowledge that the usability test did not consider how the applications were employed during an ordinary working day. Future efforts should be devoted to investigate the experience of use in a more ecological context. Furthermore, employees' acceptance of the technology should also be assessed by future research. Indeed, the introduction of portable and wearable devices open up potential privacy-related issues. Even if the solution proposed is not meant to track any worker-related data, pre-

						vious studies showed that the factors involved in the acceptance of wearable technology in the workplace are diverse
37	Vitaly V. et. al. (2019)	IEEE ACCESS	Information Technology as the Basis for Transformation into a Digital Society and Industry 5.0	The article discusses the state and prospects of development of technologies that contribute in the process of the transition from industry 4.0 to industry 5.0. The conditional pyramid of technologies which Association is capable to provide this transition is presented. New types of distributed computers, Internet of everything, multi-agent systems and technologies, ontology and knowledge bases, theory of complex adaptive systems, emergent intelligence, evergetic and enterprise architecture are considered as the main components for the transition. Boundary calculations in the context of management of data coming from the Internet of things will affect almost all companies in the economy and the public sector. They will cover the scope of activities from the automation of throughput control and data collection	The study identified a number of technological advancements that will enable the industry to transition from the old Industry 4.0 model to the new Industry 5.0 idea. The analysis reveals that a strong basis for the adoption of Industry 4.0 has been created by the growing interest in the digital economy and the wide range of practical applications of this technology.	The creation of a perfect enterprise architecture and a structured description of it will raise the standard of information support offered to the business. Without the adoption of an ideal business design, it is impossible to envision an effective transition from the existing state of the industry to Industry 5.0.

				on the quality of goods, monitoring of vehicle traffic and ending with the robotization of factories. The article presents an analysis of modern and promising technologies necessary for the organization of the digital industry in enterprises, and determining the set of necessary technologies that ensure the transition from the current state of the industry to Industry 4.0 and then to Industry 5.0. It also presents a formal description of industry 4.0 and industry 5.0, which makes it possible to present the problem as a mathematical problem that has a solution. Complex formal description of the enterprise, based on the methodology of its architecture, allows to increase the efficiency of business information support in the industry 5.0. This is necessary for the organization of the digital industry in enterprises and to determine how to ensure the transition from the current state of the industry to industry 5.0. Applying this approach to industry 4.0, then to Industry 5.0, will measure the cost of this		

				transition and make it effective.		
38	Farhan Aslam et. al. (2020)	Innovation (MDPI)	Innovation in the Era of IoT and Industry 5.0: Absolute Innovation Management (AIM) Framework	In order to achieve competitive advantage and economic growth, the current study has proposed a new framework for managing innovation called "Absolute Innovation Management (AIM)" that aims to make innovation more understandable, implementable, and a regular part of the organization's operations. The "Absolute Innovation Management" framework was created in the current study using an integrated literature review technique. By embracing innovation management as a strategy through design thinking, the absolute innovation management framework connects the innovation ecosystem with the corporate strategy of the company. Thus, increasing corporate venturing and corporate entrepreneurship to achieve competitive advantage and economic growth while meeting the needs of the IoT and Industry 5.0 era will make	The current study is noteworthy because it not only develops a new framework that significantly adds to the body of knowledge on innovation management, but also makes the idea more realistic, doable, and part of an organization's daily operations.	A new and innovative absolute innovation management (AIM) framework has been provided in this study, however more research is required to confirm the validity of the framework and to put it to an actual test. The major goal of AIM, which is to be integrated with business processes without interfering with ordinary operations, demands for additional research and attention from practitioners and academics in this area. More testing may be necessary to evaluate and validate the integration of AIM with business processes. Absolute invention is a journey, not a destination, and it has widened the field of potential study.

				innovation more user/human-centered, desirable by the customer, viable for business, and technically feasible. In conclusion, it combines innovation, design thinking, and strategy to prepare firms for the Internet of Things and the Industry 5.0 transformation.		
39	Umar Al Faruqi (2019)	Umar Al Faruqi /Jurnal Sistem	Survey Paper : Future Service in Industry 5.0	With the rapid development of technology in the digitalization era, the Industry 4.0 became a terminology that became a reference for research and development in the field of technology in various sectors. This continues to trigger a ll people to develop technology to enable better utilization in facilitating hum a life. Society 5.0 is an idea that explains the revolution in people's lives with the development of the fourth industrial revolution. The idea that will be put out is that society is undergoing a transformation that takes into account both technological and humanities-related factors. Using Artificial Intelligence, Big Data analytics, Robotics, Automation, Machine	Society 5.0 is an idea that does not have to wait for the coming. Gagan ini is an idea implementing technology in revolution industry 4.0 which would consider the humanitarian aspect by providing opportunities for solve social problems Society 5.0 needs to be encouraged to materialize research and development of science and technology supported by human resources Those who speak and are competent in making things happen. This goal needs to be promoted Together with the contribution of various sectors.	

				Learning, and the Internet of Things, certain industries and demands are starting to become digital.		
40	Dr. Mohd Javaid et. al. (2020)	Journal of Industrial Integration and Management	Critical components of Industry 5.0 towards a successful adoption in the field of manufacturing	This essay compares and contrasts Industry 4.0 with Industry 5.0 while discussing the progression of all industrial revolutions. Additionally, it highlights key components and capabilities of Industry 5.0 in the industrial sector. .	Finally, this article lists and briefly discusses seventeen essential elements of Industry 5.0. This revolution's employment of intelligent machines effectively solves practical issues. With the use of human resources' critical thinking, it offers more accuracy and accelerates industrial automation. Industry 5.0 gives the sector access to computer power that supports digital production systems and is designed to interact with other systems. Therefore, via Industry 5.0, mass personalization results in consumer satisfaction and increased value creation.	Future production systems will utilize Industry 5.0, which will automate all processes. It will catch every mistake made while creating new products. Innovative technologies are linked together to improve the interaction between people and machines. Additionally, it will be useful in the medical profession, changing how treatments and surgeries are conducted. Future developments include the introduction of Industry 6.0, which can communicate with people, machines, and other systems. In the sixth industrial revolution, production is carried out via an app by photographing a preliminary sketch and then making it.

41	Yunus Zengin et. al. (2021)	Sustainability	An Investigation upon Industry 4.0 and Society 5.0 within the Context of Sustainable Development Goals	The study was done using information gathered from a survey form with 30 questions that was sent to 335 academic staff members at Kafkas University. The data were examined using structural equation modeling using Smart PLS, confirmatory factor analysis with AMOS, and exploratory factor analysis with the SPSS software.	The analysis's findings showed that SDG9, SDG10, SDG11, SDG12, SDG13, and SDG14 had little impact on the adoption of Industry 4.0 and Society 5.0 (R2: 0.172). Additionally, it was shown that the participants' replies to the questions were significantly influenced by the day's arrangement. The survey also showed that Turkey achieved progress by focusing on antiquated procedures and lacked a leadership ideology in the fields of Society 5.0 and Industry 4.0	The study's primary weakness is that it was limited to academicians at a public institution in Kars, Turkey. However, because the subject is current and incorporates numerous technological components, it becomes impossible to obtain knowledge from the general people. In light of this, research into Society 5.0 is believed to have numerous advantages for local governments, SMEs, crisis management, human resource management, and empowering women in the workforce.
42	Candice Destouet et. al.(2023)	Journal of Manufacturing Systems	Flexible job shop scheduling problem under Industry 5.0: A survey on human reintegration, environmental consideration and resilience improvement	The purpose of the papes is to proposes the Sustainable Flexible Scheduling Problem (SFJSSP) as a scheduling issue with a focus on both people and energy efficiency. We begin by going over the literature from the last ten years on Flexible Job Shop Scheduling Problems (FJSSP) with human and/or environmental issues. Then, we examine the	In order to advance scheduling 5.0, we explore upcoming research problems and provide a mathematical model that takes human and environmental aspects into account in addition to the ones taken into account by the Classical Flexible Job Shop Scheduling Problem (CFJSSP).	This paper reviewed and analyzed how human and environmental factors are considered in the literature of FJSSP. The scheduling models and methods were transformed by the arising of Industry 4.0 concepts and technologies and are nowadays challenged by the new concerns related to the human-

				trends in industrial scheduling issues.		centricity and environment efficiency of the current Industry 5.0 context. Looking at our analysis, only few papers consider the sustainable (economic–human–environment) scheduling problem,
43	Sebastian Saniuk et. al. (2022)	Sustainability	Identification of Social and Economic Expectations: Contextual Reasons for the Transformation Process of Industry 4.0 into the Industry 5.0 Concept	The article presents the results of research obtained based on a critical analysis of the literature and surveys conducted among representatives of Polish society. As a result of the research, key social expectations as to the directions of development of the Industry 4.0 concept were identified. Recommendations for industry development focused on three areas of development—human-centric, sustainable, and resilient—were established.	The presented research results will allow the development of an investment strategy and a government policy to support the development of industry based on the human-centric digitization of the economy.	The article's authors propose additional study in the areas of the the rise of the economy 4.0 and society 5.0 within the context of sustainable development. An investigation of the human role in industrial digitalization processes. The lack of study on the social, ecological, and economic effects of the Industry 4.0 idea may not sit well with certain individuals. No possibilities of Society 5.0's future operations exist at this time.
44	Joaquín Ordieres et. al. (2023)	Computers in Industry	Toward the industry 5.0 paradigm: Increasing value creation through the robust integration of humans and machines	This study proposes a flexible architecture under the LAsim Smart FActor Plus reference framework, fostering the integration of different related data sources—processes, products and the human dimension (operators or	The proposed architecture promotes distributed component perspectives at different levels using different types of digital assets. Integrated reusable services to build composed business applications are found to help increase	The primary drawback of this study is the absence of general guidelines for choosing the appropriate ontology for summarizing the entire data model and determining the

				other agents)—to increase business value creation.	business understanding and transparency. The robustness attribute is related to the concept of persistence and seeks to reduce the degree of intervention required and thus enable integration. Use cases are presented to demonstrate the advantages provided by the proposed architecture.	integrity of the data flows because these factors depend not only on the particular application but also on the needs of the company.
45	Ayodele Emmanuel et. al. (2023)	Journal of Building Engineering	Integrated practices in the Architecture, Engineering, and Construction industry: Current scope and pathway towards Industry 5.0	This study presents a bibliometric review of 573 works on IPs in the AEC industry, which were published in 258 academic sources and authored by 1415 scholars. Three major IPs were examined, namely: integrated design process (IDP), modular integrated construction (MIC), and integrated project delivery (IPD), alongside other concepts. The Bibliometrix function in R tool (Biblioshiny) was used to analyze bibliographic data collected from Scopus.	The research networks were presented in terms of annual contributions, scientific productivity, geographical distribution, and global relevance. Bibliographic factorial analysis uncovered six underlying research clusters/elements, which were categorized into the critical elements of IPs and the enablers of IPs. The critical elements of IPs include (1) design element, (2) construction management element, (3) delivery method and supply chain element, while the enablers of IPs consist of (1) technological enablers, (2) BIM enablers, and (3) training and education enablers. Based on these clusters, the gaps in current knowledge are noted. The need to expand the current research domain on IPs in	In the AEC industry, there is a growing demand for the application and utilization of IPs and technological systems. Thus, the need to build integrated procedures, standards, and systems to assist project implementation has spurred construction management research during the last decade. This study presents a holistic perspective on IPs, which could aid practitioners' and researchers to better understand these concepts and highlight possible areas of improvement

					alignment with the core values of Industry 5.0 is discussed.	
46	David Romeroa , (2021)	ScienceDirect	Towards The Resilient Operator 5.0: The Future of Work in Smart Resilient Manufacturing Systems	The "Resilient Operator 5.0" idea, based on the resilience of human operators and human-machine systems, is introduced in this article. It offers a vision for the future of work in intelligent, robust manufacturing systems under the growing Industry 5.0 trademark. It makes recommendations on how to use Operator 4.0 and its associated technical solutions to achieve acceptable smart manufacturing systems' resilience from a human-centric standpoint.	In the framework of smart resilient manufacturing systems and Industry 5.0, this article has discussed the resilience of human operators as well as human-machine systems. It has given the "Resilient Operator 5.0" a human-centered, socially sustainable, and robust vision for the future of work in smart resilient industrial systems. A Next-Generation Operator, which develops from the Operator 4.0 vision [7] that seeks to create trusting relationships (based on interaction) between humans and machines (including automation, robotic, and artificial intelligence systems), enabling those truly smart resilient manufacturing systems to not only capitalize on the strengths and capabilities of smart machines but also to arm their smart operators with new skills and gadgets to fully capitalize New levels of productivity, efficiency, and resilience are made possible by Industry 4.0 technologies—levels that	A lot of work needs to be done in the future, especially in the area of multidisciplinary research projects, to address the complexity of resilience so that businesses can prepare their workforces and manufacturing systems for a variety of potential influences on the future of work and workplaces in the VUCA horizon.

					neither human systems nor mechanical systems can reach on their own.a theory known as "human-automation symbiosis"	
47	Diseph Emma et. al. (2022)	International Federation of Automatic Control.	Industry 5.0 Readiness – "Optimization of the Relationship between Humans and Robots in Manufacturing Companies in Southeast of Ireland	In this research, an investigation into the fears of humans about the use of cobots and robots in the manufacturing space, how companies can increase value by investing in robotics, but remain ethical and improve human resources, was carried out. Areas such as upskilling humans and reconstructing their tasks in line with industry 5.0 requirements were evaluated and the willingness of humans to learn and upskill after so many years in the field and doing manufacturing in a particular way. Critical issues associated with the adoption of autonomous robots and collaborative robots (cobots), were revealed. The findings show that the level of awareness and readiness of Industry 5.0 is still minimal. It further reveals the need for education providers to	With virtual working and automated manufacturing facilities, Industry5.0 is approaching faster than we can comprehend. Humans need to be fully prepared for the transition, and this preparation can be achieved by traditional educational providers re-evaluating and restructuring the curriculum to match these changes and predicted changes, as well as by the government making policies that accommodate and accept this transition while ensuring human safety.	In order to comprehend the existing awareness and knowledge in the field of cobots/robots by: 1) People working beyond the immediate cobots/robots workspace, it would be highly advantageous to conduct case studies in the future. pupils at secondary schools, especially those who are interested in engineering.

48	Rahul Sindhwani et. al.(2022)		Can industry 5.0 revolutionize the wave of resilience and social value creation? A multi-criteria framework to analyze enablers	Aim of this paper is to proposes a framework for analyzing I5.0 enablers for achieving sustainability by integrating human values with technology. this study was conducted in three different phases: 1) through extensive review, the list of criteria and enablers was identified; 2) Pythagorean fuzzy Delphi was used to validate the enablers against criteria; 3) a hybrid approach of Pythagorean fuzzy analytical hierarchy process-combined compromise solution was employed to calculate the weights of selected criteria and determine the ranks of enablers. A sensitivity analysis was then performed to check the robustness of this framework..	The findings show that the criterion of personal customization obtained the highest weight followed by human-machine collaboration, which will create a smart cognitive environment for humans. Human intelligence is used in more important places, which will help society focus on developing social values. The authors also put forward seven propositions about adopting I5.0 enablers for best results, taking examples from existing case studies and helping industrialists adopt I5.0 methods	The goal of Industry 5.0 is to provide society with goods and services that improve lives. However, numerous factors, like mass personalization, collaborative robotics and AI systems, sustainable practices, and the bioeconomy, were either not taken into account or were not addressed in Industry 4.0. As a result of careless human activity, nature is currently experiencing worrying upheavals. Such behaviors must change, and resilient, sustainable alternatives must be integrated into our industries and daily lives.
49	Dag Øivind Madsen et. al. (2021)	Applied System innovation (MDPI)	An exploratory bibliometric analysis of the birth and emergence of industry 5.0	In order to map the field and give a preliminary picture of the emergence and current state of the scientific literature on Industry 5.0, this study will examine the topic. From the Scopus database, bibliometric data for the years 2015 through 2021 were retrieved. It is done bibliometric studies of influential documents, authors,	Exploratory analysis has made it possible to pinpoint the overall trend in publishing as well as the Industry 5.0 research's most significant texts, sources, authors, and nations. The results demonstrate that although there is currently little research on Industry 5.0, the overall trend of publications suggests that this area of study is expanding quickly.	The usage of the Scopus database as a data source is one restriction. For instance, not all academic publications are included in Scopus, therefore some important works might have gone unnoticed. Therefore, future research might incorporate information from

				sources, and nations as well as the total publishing volume and growth trajectory.		Google Scholar and Scopus. Due to the study's dependence on Scopus bibliometrics, it is also highly influenced by the scholarly discussion of Industry 5.0 that has been written up in scholarly journals.
50	Vladimir Gorodetsky et. al. (2020)	Springer Nature Switzerland	Conceptual Model of Digital Platform for Enterprises of Industry 5.0	The concept of a digital ecosystem is examined as an open, distributed, self-organizing "system of systems" of intelligent services that may coordinate choices and automatically settle disputes through agreements between several parties. It suggests categorizing the services that will be offered by the newly established advanced digital platform and explains how they work. It supports multi-agent systems' dominant position as the fundamental software architecture and technology for creating applications that are administered by the newly presented digital platform.	The concept of a digital ecosystem of smart services for digital enterprises and DP is presented in the paper, transforming the ecosystem into a single entity. In the next era of Industry 5.0, the latter should serve as a foundation for controlling the enterprise ecosystem. The contribution of the paper focuses on the creation of the DP architecture and services.	Future research and development initiatives will focus on creating a proof-of-concept DP prototype that adheres to the Industry 5.0 idea of digital production systems.

2.2 Rationales of Study

Since the inception of Industry 5.0 concept, industrial production is more productive since both people and machines are collaborating. Production in the manufacturing sector is being increased by both human laborers and universal robots. Each of the manufacturing company's executive teams must establish the production line, then adhere to the KPIs and make sure the procedures are seamless. Making industrial and personal robots is where Industry 5.0 is going in the future. The manufacturing industry is advancing quickly, and company efficiency is rising, thanks to the development of cognitive computing and artificial intelligence technologies. Industry 5.0 seeks to create a sustainable system that relies on renewable resources, so in addition to the advantages it brings to the manufacturing sector, it also promotes sustainability. There are several rationales of this study, which are discovered below: -

- There is a strong need to identify the impact which deploying Industrial IoT (IIoT) in well-known industries like manufacturing, transportation, electricity, energy-related businesses have, and what potential benefits does it offer also to understand the challenges which must be overcome in order to embrace IIoT, and how will it alter processes and overall effectiveness in these sectors?
- Identification of essential Industry 5.0 enablers and potential applications, and how can they synchronize the effectiveness of humans and machines across many domains including intelligent healthcare, cloud manufacturing, supply chain management, and industrial production? How can Industry 5.0 increase manufacturing output and promote customer satisfaction? What are the main obstacles and outstanding issues that must be addressed if Industry 5.0 is to be successfully implemented in the ensuing days, including concerns with security, privacy, human-robot collaboration, scalability, and the need for a skilled labour force?
- How can Industry 5.0, support the progress of sustainable development principles, notably in relation to flexibility, eco-friendliness, and focus on humanity? Furthermore, how can these insights be arranged into a framework that expands their influence beyond only efficacy and output?
- Understanding the key differences between a technology-driven Industry 4.0 and a value-driven Industry 5.0.
- What challenges and levels of acceptance does Industry 5.0 encounter in businesses and industries, and what are its goals with regard to the integration of people into production systems while prioritizing technological advancement for the improvement of human welfare, well-being, health, and safety in industrial settings? What value may be created for the human element within Industry 5.0 through the use and improvement of digital technologies from Industry 4.0? In addition, how can operators become resilient and digital operators while implementing Industry 5.0 inside intelligent production systems, taking into account the

available human resources, particularly the aging workforce, within the modern industrial landscape?

- According to the analysis, a key aspect of Industry 5.0 is the incorporation of human factors into the planning of work rotation. The proposed multi-faceted approach considers sociocultural and technical elements in an effort to maximize productivity while simultaneously reducing boredom and lowering ergonomics-related dangers. The ISO 25550-2022 criteria for developing an inclusive workforce are well aligned with flexible job timelines, which generate passion and inclusion within the workforce. The well-being of employees is given a lot of weight in this study, which also offers helpful advice on how to boost productivity and modify job rotation plans to better fit the particular characteristics of different workers. The creation of metaheuristic methods, investigation of various rotation frequencies, and consideration of the effects of learning curves are some of the next projects.
- To promotion of sustainable progress, the investigation digs into the integration of CSC and I5.0 concepts. It identifies key drivers of motivation and emphasizes the importance of a modified perspective, unwavering managerial support, and organizational readiness as essential components for successful execution. It emphasizes how crucial government action and international cooperation are to achieving sustainability goals. Future research could focus on gathering more stimuli, conducting empirical studies to understand the connections, and looking at specific factors that affect motivators in a variety of organizational settings, including Micro, Small, and Medium-Sized Enterprises (MSMEs).

2.3 Gap identified from literature review: -

From the extensive literature review conducted on current research in the area of SDGs adoption in manufacturing organizations, several research gaps have been identified which are discussed below -

- Sustainability can achieve through metaverse technology, and that can help industries to transform toward Industry 5.0. There is a need of more studies on restrictions, and potential advancements in the area of Industry 5.0 and its related technologies. The need for more research into manufacturing that prioritizes people, and addresses the social, environmental, and economic effects of Industry 4.0. Further study on the Indian electrical vehicle manufacturing industry can be done to achieve sustainability.
- Exploring the opportunities presented by Industry 6.0 and Society 5.0, and integrating sustainable practices into manufacturing processes are just a few noteworthy issues.
- It is essential to conduct more in-depth research projects incorporating multidisciplinary research endeavors, case studies, case studies on the electric vehicle manufacturing industry, and the incorporation of cutting-edge technology.

- There is a need for prospective initiatives should concentrate on closely examining the use of suggested solutions, improving computational effectiveness, and evaluating the uptake of wearable and metaverse technologies.
- Need to emphasize how important it is to consider sustainability, morality, and human values when advancing the technology advancements.
- The combination of IoT, AI, and Big Data analytics offers intriguing applications for Industry 5.0 in medicine. These technologies may be used to create creative innovation ecosystems that promote security, sustainability, and responsible use.
- It is required to mention the absence of research on the social, ecological, and economic impacts of the Industry 5.0 concept. There are yet no scenarios for how Society 5.0 would operate in the future.
- There was no research found in the literature that identifies the critical success factors of Industry 5.0 implementation. The critical success factors are the important factors that need to be identified to check the impact of I5.0 implementation.
- In order to comprehend the existing awareness and knowledge in the field of cobots/robots by People working beyond the immediate cobots/robots workspace, it would be highly advantageous to conduct case studies based on such industries.
- The research lacks in the identification of various barriers of I5.0 that hinders its implementation. Also, there is no study available in the literature that proposes the solutions that can help in overcoming the barriers of I5.0.
- Record and examine the sensory and visual data of various critical factors of Industry 5.0 can be done by reviewing the graphical representation of different factors at different levels.
- There is a strong need to know about the various strategies of I5.0 implementation to UNs SDGs. Strategic analysis of any implementation can help to better understand the implementation aspects. Also, there is no research in the literature that identifies the strategies of I5.0.
- Implementation of any system is one of the major aspects and in process of achieving the SDGs of UNs, it is important to implement any system properly and effectively. After implementation, it is needed to measure the performance of implementation but there is no study present in the literature that develops a framework and measures the performance of I5.0 implementation, to achieve SDGs. Hence, there is a strong need to develop a framework and measure the performance of I5.0 implementation.
- In future communication networks, Infrastructure, storage, visibility, and Co2 emission should be minimized. These all are the challenges or limitations of Edge-AI G-IoT that can be solved through critical analysis and successful implementation of Industry 5.0.
- There is no study present in the literature where EV manufacturing industries were taken into consideration for I5.0 implementation.

3. Objectives of the Study

- ✓ To identify and examine the current status of I5.0 approaches implementation in Indian EV manufacturing organizations.
- ✓ To identify the impact of enablers of I5.0 implementations to achieve SDGs.
- ✓ To identify and to prioritize the barriers to I5.0 implementation and rank the solutions to overcome the barriers.
- ✓ To identify and rank the various strategies of I5.0 implementation.
- ✓ To develop a framework to measure the performance of I5.0 implementation.

4. Research Methodology to be adopted (*tentative*)

4.1 Research Design

Stage 1: Exploratory Research: It includes the non-numeric data gathering, clustering, and synchronization of various literature reviews. A systematic questionnaire will be designed to examine the status of Industry 5.0 approaches implementation in Indian EV manufacturing organizations and this questionnaire is based on literature research, field investigation findings, practitioner, academic, and expert interviews.

Stage 2: Descriptive Research: To identify the impact of critical success factors of Industry 5.0 and measure the performance of EV manufacturing companies.

Stage 3: Identify and prioritize the barriers to I5.0 implementation and rank the solution to overcome the barriers. To develop a framework to measure the performance of I5.0 implementation.

Stage 4: Hypothesis testing will be done with the help of Structural Equation Modeling.

4.2 Sample Design

Our sample size consists of manufacturing Industries in India, which includes only the electric vehicle manufacturing industry. These firms are selected as samples by simple random sampling methods.

4.3 Data Collection

Through prominent practitioners and academics, prepared questionnaires will be pilot-tested. The questionnaire will be developed based on their comments. The new method of data collection will be used such as via Google form, online software, and sharing questionnaires through online mode. Data will be gathered by postal surveys, in-person interviews, and emails to the company's Managerial level. The firm would be chosen based on any combination of the following criteria: listed company, turnover, workforce, cluster, and first-tier supplier.

4.4 Research Data Analysis Tools to be Used

- ✓ After receiving the data from various firms these data are filled in the statistical tools for analysis. The following is the summary of quantitative tools, which are, utilize in the analysis of our data it depends upon the firms and data available to us.
- ✓ Total Interpretive Structural Modelling (ISM) will be used to examine the current status of Industry 5.0 approaches implementation in Indian EV manufacturing companies.
- ✓ Exploratory Factor Analysis (EFA) will be run on the data from the initial survey, to examine and validate the underlying dimensions of the constructs.
- ✓ Confirmatory Factor Analysis (CFA) will be performed on data from the final survey "to assess whether the multiple measures that define a scale can be acceptably regarded as alternative indicators of the same construct".
- ✓ Structure Equation Modelling (SEM) will be used for hypothesis testing. Some other tools and techniques will also be used to determine the critical success factors of Industry 5.0. Thus, various quantitative and qualitative statistical tools and techniques such as correlation analysis, regression analysis, ANOVA, and Fuzzy Logic etc will be used to analyze responses.
- ✓ Data Envelopment Analysis (DEA) will be used to evaluate and assess the efficiency scores of sample Indian EVs manufacturing firms.
- ✓ Based on the study of an implementation framework for Industry 5.0 adoption for Sustainable manufacturing in electric vehicle manufacturing in Indian manufacturing Industries will achieved.

4.5 Multi-criteria decision-making (MCDM) methods

Few latest MCDM methods will be used based on the objectives of the research. The various experts of the field will be contacted and their suggestions and recommendations will be taken.

4.6 Software to be used

Various software used for data analysis such as SPSS, MATLAB, AMOS, and R language.

4.7 Table 2: The Methodology adopted in the research (tentative)

Industry 5.0 & Sustainable development goals related literature review	S. No.	The Objectives of the Research	Methodology adopted	Empirical case study	Research Conclusion
	1	To identify and examine the current status of I5.0 approaches implementation in Indian EV manufacturing organizations.	Expert opinion + Questionnaire survey	Pilot study	
	2	To identify the impact of enablers of I5.0 implementations to achieve SDGs.	Pythagorean Fuzzy VIKOR	Expert Based Analysis	
	3	To identify and to prioritize the barriers of I5.0 implementation and rank the solutions to overcome the barriers.	Pythagorean Fuzzy AHP + DEMATEL	Comparative analysis	
	4	To identify and rank the various strategies of I5.0 implementation.	Survey	Case study	
	5	To develop a framework to measure the performance of I5.0 implementation.	Fuzzy BSC + TOPSIS + Expert opinion + Questionnaire Survey	Pilot study	

5. Proposed Research Plan

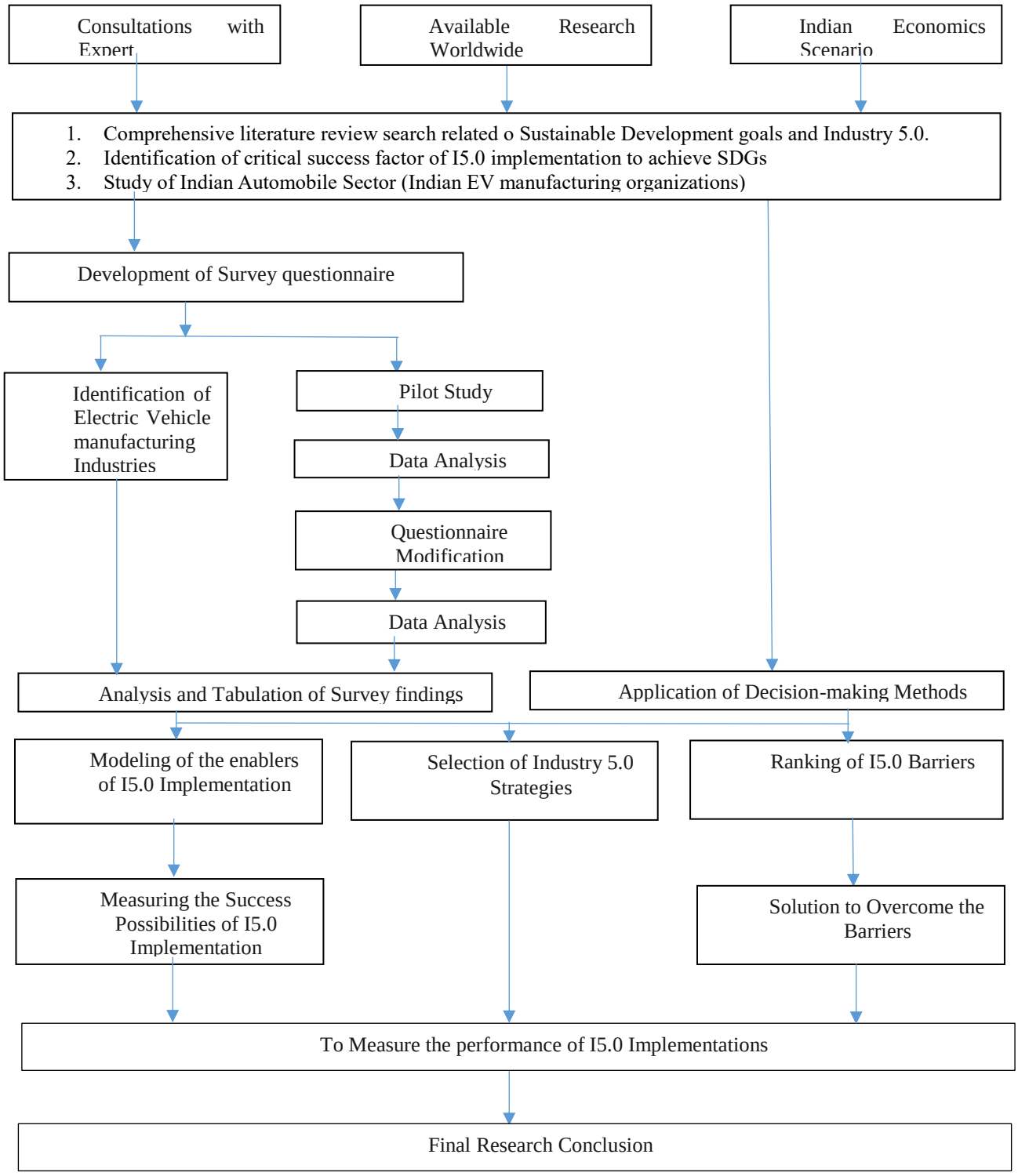
Consultations with Expert
Available Research Worldwide
Indian Economics Scenario
1. Comprehensive literature review search related o Sustainable Development goals and Industry 5.0.
2. Identification of critical success factor of I5.0 implementation to achieve SDGs
3. Study of Indian Automobile Sector (Indian EV manufacturing organizations)
Development of Survey questionnaire
Identification of Electric Vehicle manufacturing Industries
Pilot Study
Data Analysis
Questionnaire Modification
Data Analysis
Analysis and Tabulation of Survey findings
Application of Decision-making Methods
Modeling of the enablers of I5.0 Implementation
Selection of Industry 5.0 Strategies
Ranking of I5.0 Barriers
Measuring the Success Possibilities of I5.0 Implementation
Solution to Overcome the Barriers
To Measure the performance of I5.0 Implementations
Final Research Conclusion

Figure 1 – Proposed Research Plan

6. Summary of the Report

This research aims to study of I5.0 implementation to achieve SDGs in Indian EVs manufacturing organizations. An extensive literature has been conducted to check the existence and research conducted in the field of Industry 5.0 implementation. As it is known that sustainability is the major concern across, the globe and the UN's 17 SDGs are the most important practices that would want to adopt to enhance the overall productivity of the system. Through the gaps identified from the literature survey, total five objectives have been defined to achieve the overall aim of this research. The proposed objective will be achieved through sub-topics that will be identified and examine the current status of I5.0 approaches implementation in Indian manufacturing organizations, identify the impact of critical success factors of I5.0 implementations to achieve SDGs, to identify and prioritize the barriers to I5.0 implementation and rank the solutions to overcome the barriers, to identify and rank the various strategies of I5.0 implementations, and to develop a framework to measure the performance of I5.0 implementation all these sub-objectives will be achieved step by step by applying the methodology this will based on survey-based analysis for survey there will be some questionnaire will be prepared through experts and practitioners and brainstorm on that collected data through questionnaire will be analyzed.

Various MCDM methods such as AHP, DEMATEL, TOPSIS, VIKOR, ARAS, ELLECTRE, PROMITHEE, OCRA, ANP, WPM, MOORA, etc. will be used for fulfilling the objectives and sub-objectives of the research. The various experts in the field will be contacted and their suggestions and recommendations will be taken for the study. In addition, some case studies will also be conducted in Indian electric vehicle manufacturing companies. Finally, expected findings or outcomes will be proposed that are critical success factors of I5.0 to achieve SDGs. Identification and prioritization of barriers will be necessary to achieve SDGs in electric vehicle manufacturing to implementation of I5.0. The rank of various strategies of I5.O will be analyzed to provide a system to evaluate the success of the I5.0 implementation. The expected outcomes of this study may help Indian electric vehicle manufacturing organizations to achieve sustainability in their production process. Also, the UN's SDGs can be achieved through Industry 5.0. This research will be able to identify and prioritize the barriers to the implementation of I5.0 and will be able to rank the solution to overcome the identified barriers. This research will develop an integrated framework using the MCDM approach for the measurement of the performance of Industry 5.0 implementation. This research will be able to identify the impact of critical success factors of Industry 5.0 implementation to achieve the sustainable development goals in the electric vehicle manufacturing industries.

Table 3: Research Schedule

Activity	**Time Period**	**Months**
Date of Registration	May - 2022	-
Course Work	July-2022 to Feb-2023	7
Comprehensive Written Examination	July 2022 to- Feb-2023	7
Comprehensive Oral Examination/Research Proposal Viva-voce	March -2023 to Sep-2023	6
Data Collection	Jul 2023 to Dec 2024	6
Data Analysis	Jan 2024 to June 2024	6
Results and Discussions	July 2024 to Dec 2024	6
Conclusion and Thesis Submission	Jan 2025 to June 2025	6

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